The Apterygota & Ephemeroptera

Insect Diversity & Evolution series

L 10

Imperial College London

Original Classification: Insects

- Apterygotan orders
  - Diplura
  - Thysanura
  - Protura
  - Collembola

- Pterygota
  - ➢Division: Exopterygota
    - Paleopteran orders: Ephemeroptera & Odonata
    - Orthopteroid orders
    - Hemipteroid orders
  - ➢Division: Endopterygota

"Hexapoda": The tree of Life Project

- … a collaborative effort of biologists from around the world. On more than 9000 World Wide Web pages, the project provides information about the diversity of organisms on Earth, their evolutionary history (phylogeny), and characteristics.
- … TolWeb - http://tolweb.org/Hexapoda

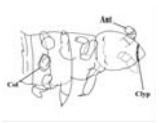
(lecture & links on www.dropdata.org → entomology)

Arthropoda

A symphylan myriapod

Hexapoda

Silurian?



Rhyniella praecursor
(Devonian chert 400-412 mya)
www.abdn.ac.uk/rhynie

Order: Diplura

Position of Diplura in hexapoda is unclear; characteristics:

- eyeless
- tentorium absent
- unique muscles and pivots in legs

Other characteristics:

- mostly white
- long, slender antennae
- two prominent cerci, either long and filiform or short and forcep-like (Japygidae)

Campodeidae

Japygidae

Order: Protura

- eyeless
- antennae absent
- tentorium absent
- fore legs enlarged, with many sensillae; front legs serve role of antennae

Other characteristics:

- very small, less than 2 mm long
- cerci absent
- legs 5-segmented
- abdomen with 12 segments as adult
- anamorphic development (segments added at moults)

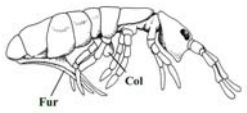
Order: Collembola
(Springtails)

- Widest distribution of any hexapod group, occurring throughout the world, including Antarctica.
- Probably the most abundant hexapods on Earth, with up to 62,000 individuals per square M.
- Found in soil, leaf litter, logs, dung, cave, shorelines, etc.
- Approx. 6000 known species.

Tomocerus longicornis

Collembolan characteristics

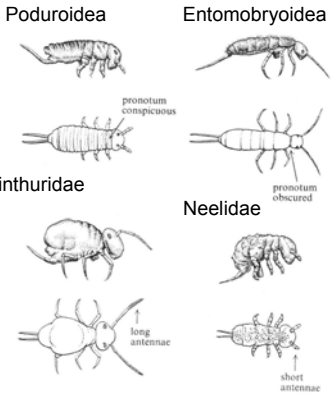
- ventral tube ("collophore") on segment 1 of abdomen (adhesive in some groups, but primarily involved with excretion and maintaining water balance)
- springing mechanism formed from retinaculum (catch mechanism) on segment 3, furcula on segment 4
- 4-segmented antennae (segments sometimes subsegmented, giving the appearance of more than 4 segments)
- 6 abdominal segments



Other characteristics:

- Indirect sperm transfer with globular stalked spermatophore
- Adults continue moulting throughout life (up to 50 moults)
- Reproductive instars alternate with feeding instars
- No Cerci

Some major groups of Collembola



Collembolan pests!

The Lucerne Flea
Sminthurus viridis

In Australia:

- Invasive sp. From N. Europe
- Chemical sprays (resurgence?)
- Biological control (with predatory mites)

… but much more likely to be beneficial

- Recycling nutrients (leaf litter *etc*.)

Springtails – – Britain's most abundant insects

Frampton & Hopkin (2001) *British Wildlife* **12** (6), 402

Class: Insecta

- Archaeognatha (bristletails)
- Thysanura (silverfish and firebrats)
- Pterygota (winged insects)

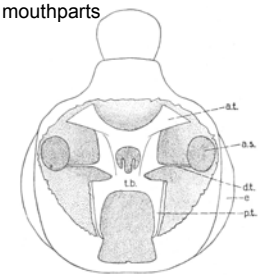
Styli on abdomen may be remnants of ancestral limbs.

… so what makes a true insect?

- lack of musculature beyond 1st antennal segment.
- Johnston's organ in pedicel (second segment) of antenna - detects movement.
- a transverse bar forming the posterior tentorium inside the head
- tarsi sub-segmented
- females with ovipositor formed by gonapophyses from segments 8 and 9
- terminal filament (telson) extending out from end of segment 11 of abdomen (subsequently lost in most groups of insects)

Insect characters

- Tentorium: 2-3 fused apodemes giving rigidity to head and better articulation to mouthparts



- Johnston's organ collection of sensory cells that detect movement of the flagellum.

first found in …

Order: Archaeognatha (Bristletails)

Petrobius maritimus photo S. Trewhella

- Originally combined with Thysanura
- mandibles with only one condyle (the joint or socket-like attachment point to the head capsule) … feature gives the order its name (*Archaeo* - beginning, *gnathos* - jaw).
- compound eyes enlarged, medially contiguous
- specialised musculature of abdomen, which allows them to jump by a rapid downward bending
- abdominal segments bear styli

Order: Thysanura (Silverfish and Firebrats)

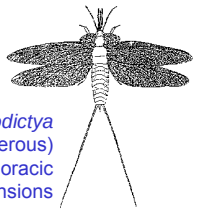
- body flattened
- long cerci and median filament
- mouthparts - two condyles ("dicondylic").
- compound eyes separate
- abdominal segments bear styli

telson

cerci

Insecta sub-class: Pterygota

How did wings evolve?



Stenodictya (Carboniferous) showing prothoracic lateral expansions

- Paleodictyopteroidea †
- Ephemeroptera (mayflies)
- Odonata (dragonflies and damselflies)
- Neoptera (bugs, beetles, wasps, moths, flies, etc.)

- Paleoptera ("old wing")
- Neoptera ("new wing")

Order: Ephemeroptera (Mayflies)

- *Ephemeros* - short-lived, *pteron* - wing
- adults do not eat.
- immature stages aquatic with gills, usually herbivorous
- fore legs of male elongated, used to grasp female in flight.
- mouthparts of adults reduced, unsclerotised.
- hind wings reduced, smaller than fore wings.
- earliest fossils - Carboniferous

Sub-imago and Imago

Sub-imago or anglers' "dun"

- ➢Dull (covered with fine hairs) - prevents wetting)
- ➢Only insects to have flying immature stage

Imago - "spinner"

Life cycle

- Eggs dropped singly (sometimes batches) onto water surface
- Nymphs:
  - ➢usually feed on diatoms, algae, *etc*., sometimes carnivorous
  - ➢plate-like tracheal gills on abdomen
  - ➢always telson + 2 cerci
  - ➢undergo up to 27 moults often taking 1 year (2 years for *Ephemera* spp.)
- Sub-imago finds resting place and moults within hours
- Imago: <1 day to 1 week (maximum).
- Males generally fly in swarms that undulate in the air 5-15 meters above the ground.

Major families (esp. N European)

1. **Ephemeridae**
2. Potamanthidae
3. Siphlonuridae
4. Ecydonuridae
5. **Caenidae**
6. **Ephemerellidae**
7. Isonychidae
8. **Baetidae**
9.
10. **Leptophlebidae**

(illustrations from Chinery, 1979)

NB: <u>not all</u> adults have central terminal filament

Ecology

- Immature & adult mayflies are an important part of food web near waterways: particularly for carnivorous fish *e.g*. trout in cold water streams, or bass and catfish in warm water streams.
- No apparent relationship species traits and habitat utilisation evident for Ephemeroptera.
  - Baetidae use many habitat types and have diverse species traits;
  - Leptophlebiidae, Heptageniidae, and Caenidae use many habitat types but each family has a rather uniform set of traits.

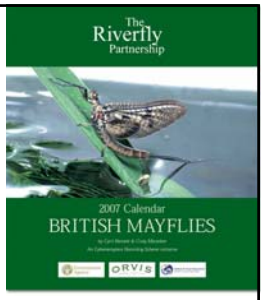
(see: Usseglio-Polatera & Tachet, 1994, *Freshwater Biology* **31**: 357)

Ephemera danica: "green-drake"

"Mohican may"

Conservation

- Little interest / knowledge of conservation status to date
- Alliance with anglers' interests
- Southern iron blue mayfly (*Nigrobaetis niger*) now listed on UK BAP
- Indicator spp.



Mayflies as indicator spp.

Biological Monitoring Working Party (BMWP) protocol

BMWP		ASPT	
BMWP Score	Quality	ASPT	Quality
Over 150!	A. Very good biological quality	Over 5.4	Very good
101 – 150	B. Good biological quality	4.81 – 5.4	Good
51 – 100	C. Fair biological quality	4.21 – 4.8	Fair
16 – 50	D. Poor biological quality	3.61 – 4.2	Poor
0 – 15	E. Very poor biological quality	3.6 or less	Very poor

Scores for each family identified are totalled, which is the BMWP score. This figure is then divided by the number of taxa (each specific organism), to give the Average Score Per Taxon (ASPT): which is independent of sample size and perhaps less influenced by season than the BMWP (Sussex Ouse Conservation Society website)

Macro inverte-brates and their scores

Example	Score	Group	Families in same score group found in the Sussex Ouse catchment	
Ephemeridae	10	Mayflies	Ephemeridae Ephemerellidae Leptophlebidae Potamanthidae	*
		Caddis flies	Brachycentridae Goeridae Lepidostomatidae Leptoceridae Phryganeidae Sericostomatidae	
Libellulidae	8	Dragonflies	Agrionidae Libellulidae	
		Caddis flies	Psychomyiidae	
Limnephilidae	7	Caddis flies	Limnephilidae Polycentropidae Rhyacophilidae	
		Mayflies	Caenidae	*
Gammaridae	6	Shrimps	Gammaridae	
		Dragonflies	Coenagrionidae	
		Caddis flies	Hydroptilidae	
		Snails	Ancylidae Neritidae Viviparidae	
Dytiscidae	5	Beetles	Dytiscidae Elmithidae	
		Caddis flies	Hydropsychidae	
		Flatworm	Dendrocoelidae Planariidae	
		Cranefly/Blackfly	Tipulidae Simuliidae	
Piscicolidae	4	Leeches	Piscicolidae (fish leech)	
		Mayflies	Baetidae	*

Summary

- Apterygota: now not recognised as monophyletic; 3 orders now classed as Hexapoda, but not insects
- Collembola, protura *etc*. important leaf litter fauna recycling nutrients
- True insects mostly winged orders + old Thysanura (& Archaeognatha separate)
- Ephemeroptera - mayflies - Palaeopteran
  - aquatic larvae and unique pre-imago stage (dun)
  - … important indicator species for quality of freshwater habitats